4. Benefits of NI validated through farmer participation and technologies made available to rural communities.

   - Assess the current use of nitrogen inputs into agricultural systems in three target areas involving rural communities.
   - Introduce crop/forage components with NI ability into current production systems in participation with farmers to assess benefits and costs.
   - Use GIS tools for scaling up and scaling out of NI technologies.
   - Evaluate the impacts of NI technologies on livelihoods and environmental benefits.

What are the expected benefits?

1. Genetic diversity in nitrification inhibition will allow genetic recombination of nitrification inhibition with other agronomically desirable traits in tropical forages and crops.

2. Discovery of natural compounds responsible for nitrification inhibition will lead to development of novel nitrogen fertilizers.

3. Gene discovery for nitrification inhibition will facilitate transfer of genes to economically important crops.

4. Integration of crop and forage components with different levels of nitrification inhibition will lead to improvements in nitrogen management.

5. Crops and forages with enhanced nitrification inhibition ability will increase productivity of agricultural systems and improve rural livelihoods.

6. Improved nitrogen management in agricultural systems will have positive impacts on human and agro-ecosystem health.

About JIRCAS

The Japan International Research Center for Agricultural Sciences (JIRCAS) is one of the several research institutes belonging to Ministry of Agriculture, Forestry and Fisheries (of Japan). JIRCAS was established in October 1993, through the reorganization of the former Tropical Agriculture Research Center (TARC) founded on June 1970. Since 2001, JIRCAS is an independent administrative institution that promotes research aimed at achieving a stable global food supply and ensuring sustainable agriculture, forestry and fisheries in harmony with the environment.

http://ss.jircas.affrc.go.jp

About CIAT

The International Center for Tropical Agriculture (CIAT, its Spanish acronym) is one of 15 food and environmental research organizations known as the Future Harvest centers. The centers, located around the world, conduct research in partnership with farmers, scientists, and policymakers to help alleviate poverty and increase food security while protecting the natural resource base. The Future Harvest centers are principally funded through the 58 countries, private foundations, and regional and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR).

http://www.ciat.cgiar.org

Exploiting biological nitrification inhibition in agriculture

Roots from *Brachiaria humidicola* (tropical grass) release inhibitors through exudates that suppress nitrification

A novel strategy for multiple socio-economic and environmental benefits

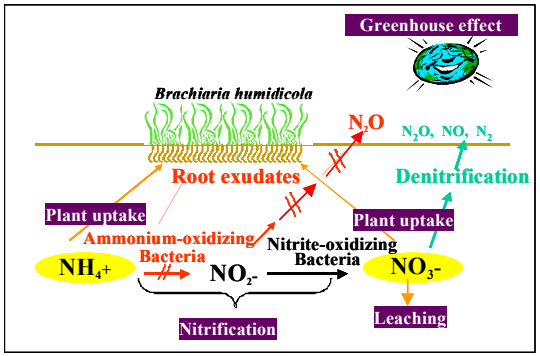
JIRCAS JAPAN

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

What is nitrification and why do we need to regulate nitrification?

Nitrification [a soil biological process whereby ammonium nitrogen (NH_4-N) is converted into nitrate nitrogen (NO_3-N)] results in substantial losses to agricultural systems (through nitrate leaching and nitrous oxide emissions) of nitrogenous fertilizers applied usually in ammonium form (see Figure).

As much as 50 to 70% of the fertilizer-N can be lost because of nitrification-associated processes, contributing significantly to global warming, destruction of the ozone layer in the stratosphere through nitrous oxide emissions, and serious nitrate pollution of surface and groundwater bodies. These environmental concerns need to be addressed for the development of productive agricultural systems that are economically efficient and ecologically acceptable. Annual direct economic cost of this N loss from agricultural systems is estimated at US$ 16.4 billion. If the nitrification process is regulated, then recovery of fertilizer nitrogen (both organic and inorganic) by crops and forages will substantially improve.



Biological processes involved in the regulation of nitrification inhibition and nitrous oxide emission by a tropical forage grass *Brachiaria humidicola* cv. Tully

How can we genetically exploit the phenomenon?

Nitrogen is the most precious resource for crop growth and yield. The proposed project is aimed at genetically exploiting the natural phenomenon of nitrification inhibition (NI) for the benefit of agricultural productivity and environmental protection. Some forage crops (e.g. *Brachiaria* grasses) have been shown to have the ability to regulate nitrification in soils by releasing inhibitors into the soil from their roots. This biological mechanism has evolved to minimize N losses associated with nitrification, thus improving N-recovery and N-use efficiency. Genetic exploitation of nitrification inhibition is possible through manipulating this natural phenomenon (e.g. *Brachiaria* grasses) and transferring these mechanisms into field crops (e.g., rice, wheat, maize and soybean) and other forages. Genetic exploitation will have a potentially enormous impact in regulating nitrification in many tropical and temperate crop/livestock systems.

What is new?

Until now the only way to regulate the rate of nitrification in agricultural systems has been through application of synthetic nitrification inhibitors or slow release nitrogen fertilizers. The proposed biological approach is novel. A major breakthrough has been the development of innovative detection tools by JIRCAS researchers that facilitated the practical exploitation of this natural biological phenomenon. The proposed research envisions development of forages and field crops that have the built-in ability to regulate the nitrification process. These improved crop and forage components will be integrated into production systems to enhance N-use efficiency and agricultural productivity while protecting the environment.

Research Program Description

Goal

To manipulate the phenomenon of nitrification in agricultural systems to increase crop yields, to reduce poverty and protect human and environmental health.

Purpose

To improve N-use efficiency and productivity in crop/forages through defining, quantifying and manipulating the natural phenomenon of nitrification inhibition while minimizing negative environmental impacts of N-fertilizer use.

Outputs/Activities

1. The natural phenomenon of nitrification inhibition (NI) in forage grasses characterized, quantified and chemical compounds responsible for NI determined.
   - Isolate, purify and determine the chemical structure of NI compound (s).
   - Determine the metabolic pathway for the synthesis and release of NI ability.
   - Develop and refine the methodologies for the detection and quantification of NI.
   - Determine the relative effectiveness of NI ability/compounds in relation to the standard synthetic nitrification inhibitors.
   - Develop methods to quantify N_2O emissions associated with NI.

2. NI ability genetically manipulated and enhanced in crops and grasses through breeding by defining genetic diversity and identifying genes responsible.
   - Screen a range of crop and forage germplasm to identify the range of genetic diversity in NI ability.
   - Initiate conventional breeding in grasses to combine high NI ability with other desirable agronomic traits.
   - Develop molecular breeding tools for genetic recombination of NI in forage grasses.
   - Isolate, sequence and clone candidate genes responsible for NI ability.
   - Test the candidate genes using genetic transformation.

3. Agricultural systems with enhanced N-use efficiency developed by exploiting the natural NI phenomenon in crops and forage grasses.
   - Establish field studies to verify the NI phenomenon in agricultural systems.
   - Quantify the impact from NI on N-use efficiency, agricultural productivity and profitability.
   - Assess the impact from NI on soil biodiversity, soil biological activity and feedback mechanisms.
   - Quantify the impact from NI on NO_3 leaching (water quality) and N_2O emissions.
   - Analyze the tradeoffs among agricultural productivity, product quality and environmental benefits as influenced by regulation of NI.